Oct. 24, 1961 W. TINLIN 3,005,627

TUNNELING MACHINE HAVING SUCTION EXHAUST MEANS

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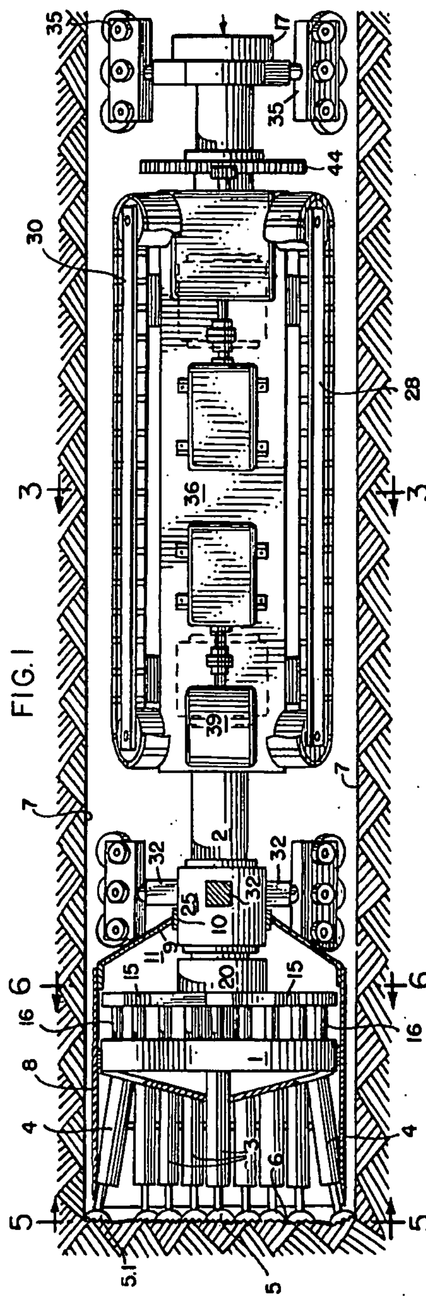

FIG. 1

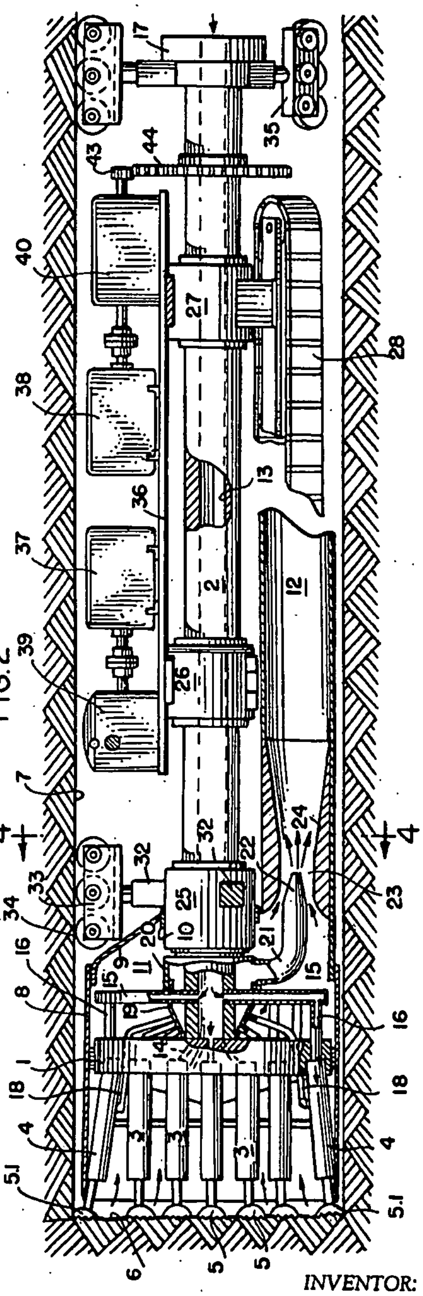

FIG. 2

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FIG. 3

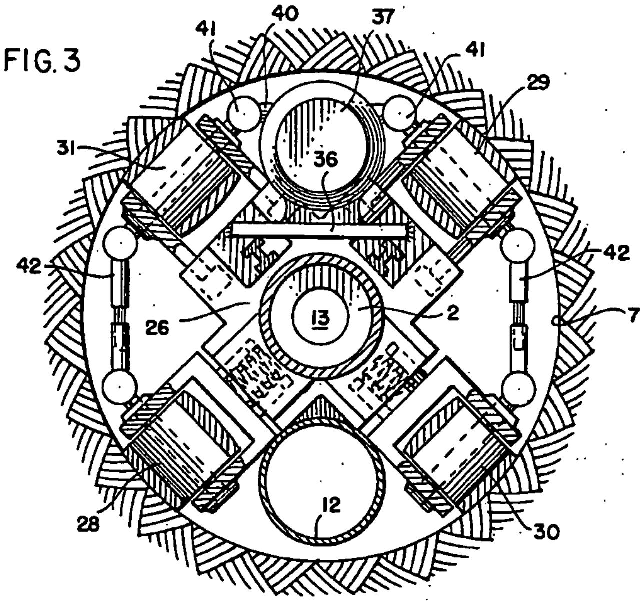

FIG. 4

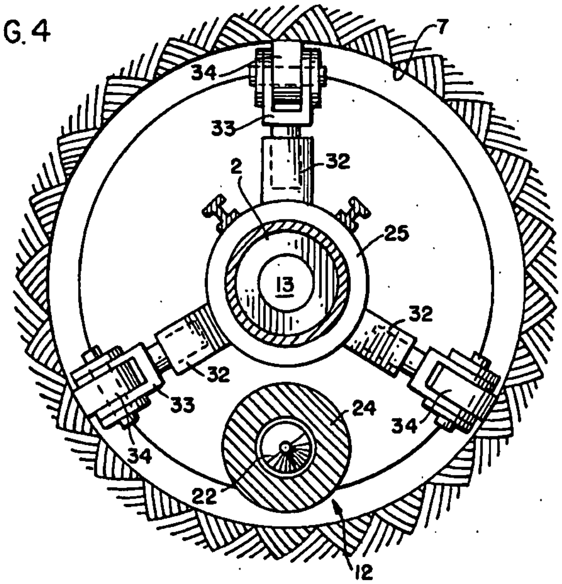

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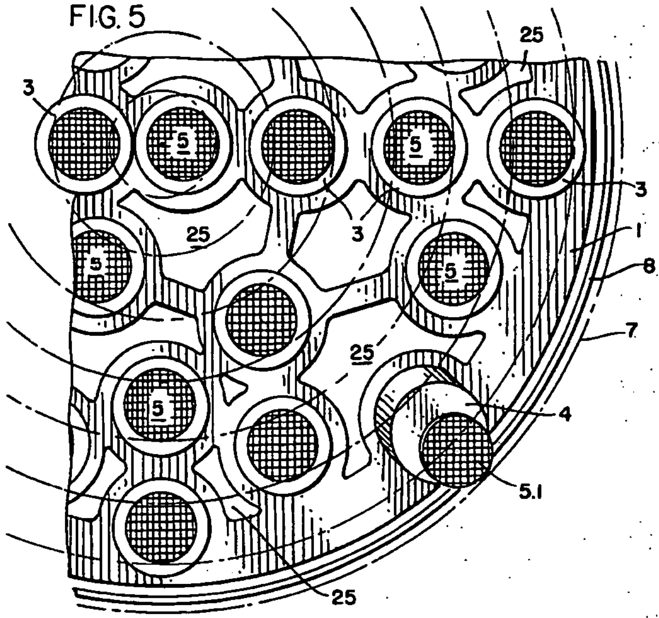
FIG. 5



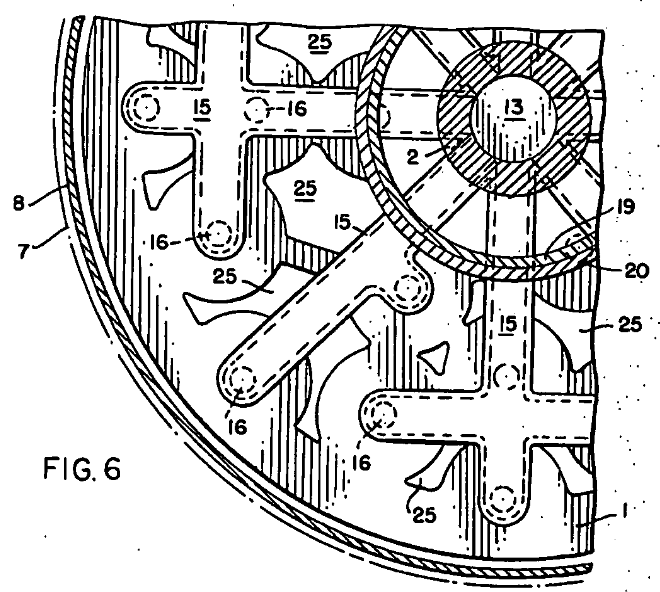


FIG. 6

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TUNNELING MACHINE HAVING SUCTION EXHAUST MEANS

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5 Claims. (Cl. 262—6)

This invention relates to improvements in tunneling machines and particularly to such machines for tunneling into rock, to form a relatively smooth walled bore of substantially any length, and which may be remotely controlled from the mouth of the tunnel.

The main objects of this invention are to provide an improved machine for tunneling into solid rock; to provide such a machine which will form a relatively large size bore in solid rock by working the entire area of the tunnel face substantially simultaneously; to provide such a machine that is automatic in its operation; to provide such a machine that will automatically remove its cuttings from the tunnel face at almost the instant that they are formed; to provide such a machine that will automatically deliver and discharge the cuttings to the tunnel mouth; to provide such a machine with which the cuttings are of relatively small granular form for easy removal from the tunnel face and conveyance to the tunnel mouth; to provide such a machine which may be remotely controlled from the tunnel mouth for both direction of the tunnel bore and speed of operation; to provide an improved tunneling machine whereby the character of the matrial being worked or tunneled into can be continuously determined from the tunnel mouth; and to provide an improved rock tunneling machine that is self-propelled, substantially automatic in its operation, and which will form a clean bore of substantially any length without the need of manual work within the tunnel.

A specific embodiment of this invention is shown in the accompanying drawings, in which:

FIGURE 1 is a schematic plan view of an improved tunneling machine with the chassis or frame parts omitted and with other parts broken away to show the operational components and illustrate the nature of the invention.

FIG. 2 is a side view of the said machine, also with frame parts omitted and other parts broken away, to illustrate the manner by which the cuttings and debris are removed.

FIG. 3 is a sectional elevation as taken on line 3—3 of FIG. 1 to show an arrangement of crawler drive means for the machine.

FIG. 4 is a similar view as taken on line 4—4 of FIG. 2 showing the arrangement of means for steering and laterally stabilizing the work head of the machine in its operation.

FIG. 5 is a fragmentary view as taken on line 5—5 of FIG. 1 showing the working face of the work head of the machine, and

FIG. 6 is a fragmentary sectional view as taken on line 6—6 of FIG. 1 to illustrate a manner of supplying compressed air for operation of the individual rock cutting devices carried by the work head of the machine.

The essential concept of this invention is to provide a rock tunneling machine having a rotatable or rotatably oscillating work head on which are mountd a plurality of rock cutting tools of the jack hammer type, the work head and rock cutting tools being substantially surrounded by an enclosure or air shield to which a suitable air exhausting or suction means is connected whereby air is drawn to the face or heading of the tunnel around the periphery of the enclosure or shield and is then exhausted rearwardly from the tunnel face through substantially the entire area of the work head to remove the cuttings generated by each power tool as rapidly as they are produced, the work head, cutting tools and surrounding enclosure being supported on and carried by a suitable self-propelled carriage or frame for operation longitudinally of the tunnel bore. The cuttings tools are mounted on the work head in such a manner with relation to each other as to work the entire area of the tunnel face or heading during each cycle of work head rotation or oscillation; and the cutting tools adjacent the periphery of the work head are angulated outwardly from the axis of the work head so that the formed diameter of the tunnel face is somewhat greater than the outside diameter of the work head enclosure or air shield. It is, therefore, a part of the concept of this invention that the diameter of the work head and the air shield enclosure therefor is to be only so much less than the diameter of the tunnel bore that is formed as to provide sufficient peripheral space between the air shield and the tunnel wall for the entry of such air as is necessary to pick up and remove the cuttings generated at the tunnel face by the cutting tools. Thus, for example, a machine having a work head four feet in diameter will have its cutting tools so disposed as to form a tunnel face of about four and one-half feet in diameter.

Tunneling machines employing a hammer type of cutting tool on a rotatable or oscillating head are, generally speaking, known in the art, and it has even been proposed, heretofore, to remove the cuttings from the tunnel face by an air suction exhaust system located on the axis of a revolving work head carrying peripherally mounted cutting elements. A primary difficulty with these prior machines, however, lies in the fact that the means for removing the cuttings created by the cutting tools has been insufficient to keep the tunnel face clear of debris, or too slow in its operation to permit an economically practicable cutting rate and speed of forward travel of the tunneling machine. The present invention is intended to overcome these difficulties and to provide a tunneling machine which is limited in its speed of operation only by the number and cutting rate of impact type of cutting tools.

In the form shown the improved tunneling machine comprises a work head **1** rigidly mounted on the forward end of a hollow drive shaft **2** which in turn is supported on a suitable self-propelled carriage, the details of which are not shown, whereby the drive shaft **2** is disposed to extend along the axis of the tunnel being formed. The work head **1** is disposed in a plane normal to the axis of the shaft **2** and supports a plurality of impact cutters **3**—**4** arranged to project forwardly from the work head **1** to engage the tunnel face, and, as indicated in FIGS. 1, 2 and 5, the outermost cutting tools **4** are canted outwardly relatively to the periphery of the work head **1** so that the bits or cutters **5** carried by the tools **4** will work a greater diameter of the tunnel face **6** than the diameter of the work head **1**.

It will be understood that the cutting tools may be arranged to operate on a common plane, as shown in FIGS. 1 and 2, or arranged so that the central cutting tools will project forwardly from the work head **1** a greater distance than the outermost cutting tools 4, with the cutting tools intervening being at a gradually lesser distance than the foremost cutting tool, so that the tunnel face or heading **6** will have a somewhat conical forwardly projecting form; and that in any event the entire area of the tunnel face or heading will be worked in the course of each cycle of work head operation.

As shown in FIGS. 1 and 2, the work head **1** is of somewhat less diameter than the diameter of the tunnel bore **7** and the entire work head is surrounded by a cylindrical axially extending enclosure or air shield **8**, which has an open forward end located as close as practicably possible to the cutters **5** and the tunnel face **6**. The external diameter of this enclosure or air shield **8**

is also somewhat less than the diameter of the tunnel bore 7, and the rearward end of the enclosure has a slip joint connection with a rearwardly extending hood 9, which is closed about the shaft 2 by means of an air tight seal 10 on a forward journal or bearing for the shaft, thereby providing an enclosed air chamber 11 on the rearward side of the work head 1.

The hood 9 is suitably connected to an exhaust duct 12 which leads rearwardly of the machine and thence to the tunnel mouth, and by means of suitable suction producing apparatus connected with the exhaust duct 12 a continuous suction or partial vacuum is maintained on the enclosed air chamber 11 for the purposes hereafter to be described.

In the arrangement shown in the drawings the rock cutting tools 3 and 4 which are carried by and project forwardly from the face of the work head 1, are of the fluid-pressure-operated impact or hammer type, and the cutters or bits 5 may be of any appropriate form for rock work. The fluid pressure, which may be steam or compressed air, for these tools 3 and 4 is supplied by way of the hollow main shaft 2 which has a central passage 13 leading to the work head 1. As indicated in FIG. 2 those power tools 3 adjacent the center of the work head 1 are provided with direct connections 14 leading through the work head 1 to the passage 13 on the interior of the shaft 2, and those power tools outwardly of the center portion of the work head 1 are supplied by radial manifolds 15 which are mounted on the shaft 2 rearwardly of the work head 1 and directly connected with the passage 13 within the shaft 2. These manifolds have suitable branch connections 16 which lead to the respective power tools, there being one connection 16 for each tool. The power tools 3 and 4 are all arranged to operate in unison and the starting and stopping of the tool operation is effected by suitable valve or control means, not shown, regulating the volume and pressure of the actuating fluid supplied to the rear end of the shaft 2. Since the shaft 2 is rotated or oscillated about its axis during the operation of the machine, it will be understood that the fluid pressure supply connection to the rear end of the shaft 2 will be by means of a rotary or swivel joint indicated generally by the numeral 17.

As shown, the exhaust fluid from the power tools 3 and 4 is led from each tool by a suitable conduit 18 to a common collector chamber 19, which surrounds the shaft 2 on the rear side of the work head 1 and within the air chamber 11. This collecting chamber 19 extends rearwardly beyond the air manifolds 15 and is connected by suitable rotary joint with a relatively stationary hood 20 which surrounds the shaft 2, and the hood 20 has a conduit 21 which leads rearwardly through the chamber 11 to terminate in a suitable nozzle 22 extending centrally into the throat of a restricted inlet opening 23 leading from the chamber 11 into the exhaust duct 12 by way of a gradually expanding conical passage 24, the throat 23 and the expanding passage 24 together with the nozzle 22 comprising a suction producing arrangement of the "Venturi" type.

With this arrangement the exhaust fluid from the hammers 3 and 4, which is at a pressure of about 30 p.s.i. or more, by being discharged to the collecting chamber 19, and thence through the connection 21 to the nozzle 22, will in many cases produce sufficient suction at the "Venturi" throat 23 to pull a sufficient partial vacuum on the air chamber 11 that the volume of air entering the air shield 8 at the tunnel face and from around the air shield periphery will pick up the rock cuttings as fast as they are generated by the cutters 5, and convey such cuttings through the work head 1 into the chamber 11 and thence into the exhaust duct 12 by which such cuttings will be conveyed to the tunnel mouth. It will be understood, of course, that as the length of the exhaust duct 12 increases it will be necessary to install booster suction devices to overcome the inherent resistance to air flow through the exhaust duct 12, and to maintain sufficient velocity of flow to keep the rock cuttings in suspension in the air stream. Also, it will be understood that in those cases where the fluid exhaust from the impact cutters is not used as a suction producing means for evacuating the chamber 11, the suction on the exhausting system may be generated entirely by blowers or fans suitably connected to the exhaust conduit 12.

The work head 1 may be of any suitable structure and form to mount and support the jack hammers 3 and 4, and yet provide sufficient spaces in the structure for suitable openings between the several jack hammer bodies for the passage of air and rock cuttings from the tunnel face rearwardly through the work head 1 and into the chamber 11. Also, the jack hammer bodies must be so disposed or arranged on the work head that the arcuate paths of the cutters or bits, which paths are generated by angular movement or rotation of the work head 1, will overlap radially from the center of the work head outwardly to and beyond the greatest radial dimension, or periphery, of the work head. This is necessary in order that the entire area of the tunnel face 6 will be worked by the cutters during each cycle of work head rotation or oscillation in the course of its angular movement about its axis.

Thus a typical plan or arrangement for disposition of the jack hammers and their cutting heads or bits 5 is illustrated in FIGURE 5, wherein the circles identified by the numerals 3 and 4 indicate the areas occupied by the jack hammer bodies, and the circles 5 and 5.1 indicate the areas of the working faces of the individual cutters actuated by the respective jack hammers. As shown, the radially outermost or the peripherally disposed cutters 5.1 are arranged to extend radially outward beyond the air shield 8 to the periphery of the tunnel bore 7 that is formed by the machine in its operation. This radial projection of the cutters 5.1 is accomplished by mounting the respective jack hammers so that they diverge outwardly from the work head axis as shown in FIGS. 1 and 2.

As indicated in FIGURE 5, the work head 1 is a radially extending body of grid-like formation, concentrically mounted on the main shaft 2, and of such construction as to provide rigid support for the jack hammer bodies 3 and 4, sustain their collective reactive force for transmission to the shaft 2, and at the same time leave as much opening as is practically feasible between the jack hammer bodies and axially through the work head. As shown these openings 25 are formed and disposed to extend over as much of the area of the work head as possible, so that air coming from around the outside of the air shield 8 can enter and pass through the work head 1 as close as possible to the cutters and in the course of its travel pick up and convey the cuttings as they are generated by the cutters in their work on the tunnel face or heading 6.

FIGURE 6 shows the rear side of the work head 1, and the disposition of the headers 15 with their branch conduits 16, which in turn supply the pressure fluid for operation of the jack hammers 3 and 4. This view also illustrates the appearance of the rear side of the work head as far as the openings 25 are concerned, and it will be understood that the air conveying the rock cuttings from the cutters 5 and 5.1 passes through these openings into the chamber 11, on the rear side of the work head 1, and thence to the exhaust duct 12 whereby the cuttings are conveyed to the tunnel mouth.

From the foregoing, it will be apparent that the structure thus far described is of such character as to fulfill the essential concept of this invention of providing a rotationally movable work head having a multiplicity of forwardly projecting rock cutting tools mounted thereon and enclosing the work head-cutting tool assembly in an air shield which extends substantially to the tunnel face from an enclosed chamber behind the work head and

from which air is continuously exhausted by a suitable air moving apparatus, the air shield 8 having its greatest radial dimension less than that of the tunnel being formed and being open for the entry of air only at its forward end, adjacent the cutter heads or bits, whereby the air drawn into the air shield from around its periphery passes across the tunnel face and picks up and conveys the rock cuttings through suitable openings in the work head to the air chamber and thence to the air exhaust duct. Thus, with the apparatus shown, the work head-jack hammer assembly functions substantially as an impact type of rock cutting means capable of continuously working a relatively large tunnel face area at a relatively high speed or rate of forward travel.

The work head and main drive shaft assembly must, of course, be supported on a suitable carriage capable of holding the main shaft centrally in the tunnel bore, absorbing and counteracting the reactive force of the jack hammers when they are operating, and driving the work head assembly progressively forward as the tunnel face is cut away. No attempt has been made to illustrate the framework of the carriage structure, which is essentially a matter of mechanical design. However, FIGURES 1 to 4, inclusive, are intended to indicate the primary components which must be embodied in and supported by the carriage structure. These components are not illustrated in detail since there are many suitable types and arrangements of these components that may be employed, and it is intended only to illustrate herein the functional relationship of the several components in the carriage assembly as a whole.

Thus, as illustrated in FIGURES 1 and 2, the carriage assembly may embody a plurality of thrust bearings 25, 26 and 27, in which the main shaft 2 is suitable journaled and supported, these thrust bearings being rigidly integrated into the framework of the carriage assembly. Also, as indicated in FIGURES 1, 2 and 3, the carriage assembly will include a plurality of endless crawler tracks on which the carriage is supported from the tunnel side wall, and by means of which the carriage may be driven in the axial direction of the main shaft 2 in either the forward or reverse directions. As herein illustrated, four crawler track units 28, 29, 30 and 31, are employed, the crawler track units being arranged in diametrically opposed pairs and the pairs being arranged at right angles to each other, so that there will be a supporting and driving crawler track for each quadrant of the tunnel bore 7. As shown, the crawler track units are connected together and to the carriage frame by means of the thrust bearings 26 and 27. Preferably, the mounting and connections of the crawler track units to the frame and the thrust bearings 26—27 are of the spring or hydraulically loaded type, arranged to normally urge the crawler units radially outward with respect to the machine frame and the thrust bearings 26—27.

It will be understood that the crawler tracks are to be suitably cleated so as to provide a firm grip on the tunnel wall 7, sufficient to sustain the torque and thrust load of the entire machine during its operation and to simultaneously urge the machine in the forward direction so as to keep the rock cutting tools continuously engaged with the tunnel face or heading.

As shown in FIGURES 1 and 2 the forward end of the machine comprising the work head and the cutting tools, together with that portion of the main shaft cantilevered forwardly from the thrust bearing 26, are further supported by angularly spaced stabilizers 32 projecting radially from the forward thrust bearing 25 to engage the tunnel side wall. As shown, these stabilizers 32 are integrally mounted on the forward thrust bearing 25 and each comprise a telescoping extension 33 having suitable rollers 34 for engaging the tunnel wall 7. The extensions 33 are resiliently loaded to bear outwardly against the tunnel wall, and at least two of the stabilizers are arranged to adjustably vary the pressure against the tunnel wall by some suitable mechanical or hydraulic means, not shown, whereby the shaft 2 can be tilted relative to the tunnel axis rearward of the machine to vary the direction that the machine is to travel. It is for this reason that the crawler units are resiliently mounted to the carriage structure.

Also, as indicated in FIGURES 1 and 2, similar stabilizing means 35 are provided at the rear end of the machine to hold the rear end of the shaft 2 in a central position in the tunnel bore and to prevent side sway or whip of the machine during its operation.

As shown in FIGURES 1, 2 and 3, the carriage structure is provided with a suitable platform 36, on which are mounted the drive means for the crawler units and for rotating the main shaft 2. The drive means for both the carriage and the shaft may be of any suitable type comprising power units 37 and 38, and suitable transmission means 39 and 40, which include a fluid coupling arrangement, especially on the carriage drive, whereby a constant forward urging of the carriage toward the tunnel face can be maintained during operation of the work head. As indicated in FIGURE 3, the carriage drive 37—39 may be connected to drive all of the crawler units simultaneously, the transmission unit 39 being directly connected to the upper crawler units 31 and 29, by a drive shaft 40, and suitable universal joints 41; and the crawler units 29 and 31 being connected to the crawler units 30 and 28 respectively by suitable telescoping shafts 42, which also have universal joint connections with the forward crawler unit axles.

The drive for the main shaft 2 may be such as to provide either for full rotation of the main shaft in one direction, or for angular oscillation of the main shaft sufficient for the cutter bits to fully work the tunnel face area. In either case suitable drive connection between the transmission unit 40 and the shaft 2 is provided, as indicated at 43 in FIGS. 1 and 2. It will be understood, of course, that the motor means 38, or the transmission unit 40, will be made capable of remote control for regulation of the turning rate of the shaft 2 according to the nature of the material being tunneled by the machine.

It will be understood also that the carriage structure herein shown and described is intended to illustrate only the nature of the operating components of the machine, since no invention is claimed for the carriage unit per se in the present disclosure, and the carriage unit may be of any suitable design.

In the operation of the improved tunneling machine compressed air or other fluid pressure means in the required volume and at the required pressure may be supplied from any suitable source, not shown, to the central passage 13 in the main shaft 2, by way of a suitable connection to the swivel coupling means 17 at the rear end of the main shaft 2. Assuming that compressed air is used, it will be seen that such air is delivered to the jack hammers 3 and 4, mounted on the work head 1, by means of the air passages 14 at the central part of the work head and by means of the manifold 15 and the branch connections 16 which lead to those jack hammers located outwardly of the central area of the work head 1. The machine is driven forwardly in the tunnel by the crawler units at such a rate as to keep the cutters 5 in engagement with the tunnel face 6, and the operation of the jack hammers 3 and 4 will cause rapid impact-cutting action on the tunnel face to crush and pulverize the rock material operated upon. The exhaust air from the jack hammers 3 and 4, which will be at a pressure of thirty or more pounds per square inch, will be delivered by the conduits 18 to the collecting chamber 19—20, and thence to the nozzle 22 on the conduit 21, and discharged into the "Venturi" arrangement 24 at the inlet end of the main exhaust conduit 12 thereby inducing a relatively high suction on the chamber 11 which encloses the rear end of the work head 1. The

suction on the chamber 11 will create a large volume of air flow from around the periphery of the air shield 8 to the tunnel face, and thence radially inward and rearwardly, through the openings 25 in the work head 1, into the chamber 11. The air flow passing radially inward across the tunnel face 6 will pick up and convey the pulverized rock cuttings through the work head 1, into the chamber 11 and thence to the exhaust conduit 12 by means of which the cuttings are conveyed to the tunnel mouth. Suitable boosters, not shown, will be connected to the main exhaust conduit 12 as may be necessary to maintain the velocity of air flow therethrough sufficient to suspend and convey the rock cuttings, and the cuttings may be delivered to a suitable collecting apparatus at the tunnel mouth for further disposition.

As the tunnel face is cut away by impact action of the cutters 5, the machine will be driven continuously forward by means of the crawler units of the carriage, and since the cuttings are removed as rapidly as they are created, the operation of the machine will be continuous and the tunnel bore will at all times be clean. Also, as the cutters operate against the tunnel face the shaft 2 will be continuously rotated or oscillated, so that the entire area of the tunnel face will be worked during each cycle of work head rotation or oscillation, the disposition of the jack hammers on the work head 1 being such that the paths of the cutters 5 will overlap radially as the work head revolves. Thus, the machine will continuously and at a substantially uniform rate cut its way into the rock into which the tunnel is to be made and full control of the operation can be had from the tunnel mouth.

The main advantages of this invention reside in its relatively high speed self clearing operation whereby a smooth walled, clean bore can be made of a size large enough for a man to walk into; in the fact that the rock cuttings are automatically cleared from the tunnel face, as they are formed, by pneumatic means which permits continuous removal of the cuttings to the tunnel mouth while the machine is in operation; and in the fact that the machine can be readily controlled and operated from a remote location which obviates the necessity of workmen attending the machine in the tunnel while it is in operation.

Although but one specific embodiment of this machine is herein shown and described it will be understood that numerous details of the construction shown may be altered or omitted without departing from the spirit of this invention as defined by the following claims.

I claim:

1. A tunneling machine comprising a rotatably mounted work head having a plurality of cutting tools projecting forwardly therefrom, each of said tools having an annular cutting bit and said tools being of such number and so disposed on said work head that the arcuate cutting paths generated by angular movement of said bits about the work head axis will overlap radially from the center of the work head outwardly to the periphery thereof, means for turning said work head about its axis, an annular shield concentrically surrounding said work head, said shield being open at its forward end and extending forwardly of the work head substantially to the work plane of the radially outermost cutting bits, said shield being closed rearwardly of the work head to provide an enclosed chamber behind the work head, the maximum radial dimension of said shield from the work head axis being less than the radius of the cutting path of the radially outermost cutting bits carried by said work head for permitting passage of air to the said work plane along the tunnel wall, and suction means connected to said chamber adjacent the periphery of its rearward end for exhausting air from within said shield rearwardly of said work head, said air entering said shield radially at the forward end thereof and passing across said work plane to entrain cuttings generated by said bits, and said

work head having openings therethrough for passage of said air and entrained cuttings into said enclosed chamber.

2. A tunneling machine comprising an annular work head mounted for rotation about a normally fixed axis and having a plurality of cutting tools projecting forwardly therefrom substantially in the direction of said axis, each of said tools having an annular cutting bit and said tools being of such number and so disposed on said work head that the cutting paths of said bits generated by angular movement of the work head about its axis will overlap radially from the center of the work head outwardly to the maximum radial dimension thereof, a shaft supporting said work head and extending axially rearward therefrom, means for turning said work head about its axis, a cylindrical shield concentrically surrounding said work head and extending forwardly of the work head substantially to the cutting plane of the radially outermost cutting bits, said shield being open at its forward end and closed about said shaft rearwardly of the work head to provide an enclosed annular chamber behind the work head the maximum radial dimension of said shield being less than the radius of the cutting path of the radially outermost cutting bits carried by said work head, and suction means connected to said chamber adjacent the periphery of its rearward end for exhausting air from within said shield rearwardly of said work head, said work head having openings extending axially therethrough between said cutting tools for the passage of an air and air borne cuttings from the cutting plane of each of the bits to the interior of the said chamber behind the work head.

3. A tunneling machine comprising an annular work head mounted for rotation about a normally fixed axis and having a plurality of annular impact cutters projecting forwardly therefrom and fixedly mounted thereon, said cutters being of such number and so disposed on said work head that the cutting paths of the cutters generated by angular movement of the work head about its axis will overlap each other radially from the axis of the work head to the radially outermost dimension thereof, a shaft supporting said work head and extending axially rearward therefrom, a cylindrical shield concentrically surrounding said work head, said shield being open at its forward end and extending forwardly of the work head substantially to the cutting plane of the radially outermost cutters and being closed about said shaft rearwardly of the work head to provide an enclosed chamber behind said work head, the outer diameter of said shield being less than the outer diameter of the cutting path of the radially outermost cutters on said work head, and means connected to the rear end of said enclosed chamber adjacent its periphery for exhausting air from said chamber rearwardly of said work head, said work head having axially extending openings therethrough between said cutters for the passage of air and air borne cuttings from the work plane of each of the cutters to said enclosed chamber, said air entering said shield radially at the forward end thereof and passing across the said work plane to enter said work head openings.

4. A tunneling machine comprising a work head mounted for rotation about a normally fixed axis and in a plane normal thereto, movable carriage means for supporting said work head, and means on said carriage for turning said work head about said axis; a plurality of fluid pressure actuated cutting tools mounted on said work head and projecting axially forward therefrom, said tools being of such number and so disposed relative to each other on said work head that the arcuate cutting paths of the tools generated by angular movement of the work head about said axis will overlap radially from the center of the work head outwardly to the maximum radial dimension thereof, means for supplying fluid pressure to each of said cutting tools, a shield concentric with said axis and annularly surrounding said work head and extending both forwardly and rearwardly thereof,

the forward end of said shield being open and located substantially at the cutting plane of the radially outermost cutting tools on said work head and the rearward end of said shield being closed to provide a hollow chamber on the rearward side of said work head, the maximum radial dimension of said shield being less than the radius of the cutting path of the radial outermost cutting tools on said work head, an enclosed collecting chamber on the rearward side of said work head and within the first mentioned chamber, conduit means for leading exhaust fluid from each of said cutting tools to said collecting chamber, a suction conduit connected to the first mentioned chamber for exhausing air therefrom, and means for discharging fluid pressure from said collecting chamber into said suction conduit for inducing suction on said first mentioned chamber, said work head having openings therethrough between said cutting tools for the passage of air from the open end of said shield to the rearward side of said work head and into said first mentioned chamber.

5. A tunneling machine comprising a shaft having an annular work head mounted at one end thereof in a plane normal to the shaft axis, carriage means for supporting said shaft, and means for turning the work head angularly about the shaft axis; a plurality of fluid pressure actuated impact cutting tools mounted on said work head and projecting therefrom in the direction opposite said shaft, each of said cutting tools having an annular cutting bit and said tools being of such number and so disposed on said work head that the arcuate cutting paths of the bits, generated by angular movement of the work head about its axis, will overlap radially from the center

of the work head outwardly to the maximum radial dimension thereof, and means for supplying fluid pressure to each of said cutting tools; a cylindrical shield concentric with the shaft axis and closely surrounding said work head, said shield being open at its forward end and extending forwardly of the work head substantially to the plane of the radially outermost cutting bits, the rearward end of said shield being closed about said shaft rearwardly of the work head to provide an annular chamber on the rearward side of the work head substantially concentric therewith, the maximum radial dimension of said shield being less than the radius of the cutting path of the radially outermost bits of the cutting tools on said work head, and suction means connected to the rearward end of said chamber adjacent the periphery thereof for exhausting air from said chamber rearwardly of said work head; said work head having openings therethrough adjacent each of said cutting tools for the passage of air and entrained cuttings from the work plane of said cutting bits at the open end of said shield to the chamber at the rear of the work head.

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